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EXTRACARDIAC CAVOPULMONARY CONNECTION OF FONTAN PROCEDURE WITH AUTOLOGOUS PEDICLED PERICARDIUM WITHOUT CARDIOPULMONARY BYPASS

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Total cavopulmonary connection has been proposed as a rational alternative to atriopulmonary connection for complex Fontan operation. The extracardiac conduit technique has gained favor because it streamlines the venous flow pattern and reduces the incidence of atrial arrhythmias. Unfortunately, extracardiac conduits with prosthetic tube grafts have no potential for growth, so their application in extremely young children may not be warranted.

Hvass and associates[1] have reported bicaval pulmonary connection in tricuspid atresia with an extracardiac tube of autologous pedicled pericardium to bridge the inferior vena cava (IVC) to the pulmonary artery. Pedicled pericardial tubes may be an attractive vascular substitute for right heart bypass. This nonthrombogenic material retains its growth potential and has shown its ability to allow unrestricted flow from the IVC to the right pulmonary artery.

A 7-month-old boy with a single right ventricle, transposition of the great arteries, and pulmonary stenosis underwent extracardiac Fontan operation with the use of a pedicled pericardial roll between the IVC and the right pulmonary artery without cardiopulmonary bypass.

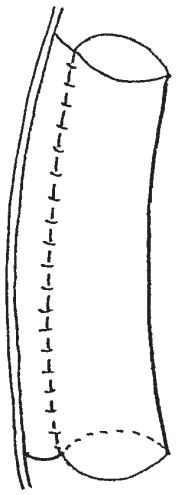

Fig 1. Autologous pedicled pericardial roll (18 × 70 mm) was made.

Clinical summary. The patient initially underwent a balloon atrial septectomy. Cyanosis gradually improved after that. At an age of 2 years and 8 months and body weight of

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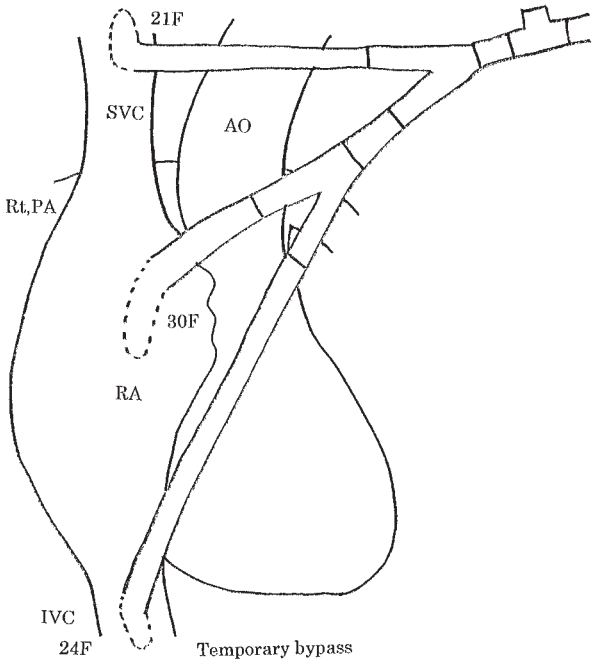

Fig 2. Temporary bypass. First, SVC and right pulmonary artery *(Rt.PA)* anastomosis was performed with SVC and right atrial *(RA)* temporary bypass. Next, extracardiac cavopulmomary connection was performed with temporary bypass. *AO,* Aorta.

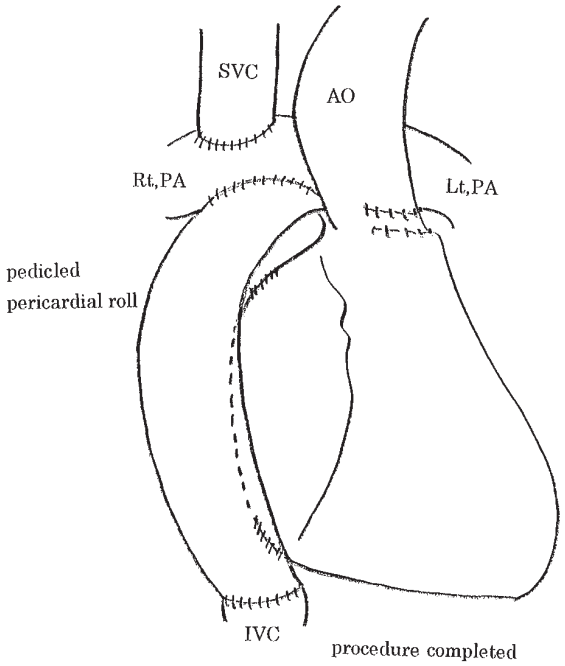

Fig 3. Extracardiac total cavopulmonary connection was completed with autologous pedicled pericardial roll. *AO,* Aorta; *Rt.PA,* right pulmonary artery; *Lt.PA,* left pulmonary artery.

11 kg, the boy was referred for a Fontan procedure because of worsening cyanosis.

Preoperative cardiac catheterization was performed. Right ventricular pressure was 84/3 mm Hg, the main pulmonary artery pressure was 26/11 (right heart catheterization 19) mm Hg, the right pulmonary artery pressure was 25/10 (15) mm Hg, the left pulmonary artery pressure was 26/12 (19) mm Hg, and the ascending aorta pressure was 86/48 (62) mm Hg. The pulmonary vascular resistance index was 0.92 Wood units/m^2. Right ventricular end-diastolic volume index was 114.5 mL/m^2, 210.9% of the normal value, and right ventricular ejection fraction was 46.3%. Resting arterial oxygen pressure was 41 mm Hg, with a hemoglobin level of 18 g/dL.

The operation was performed through a median sternotomy. The first step was to create a large pericardial flap. The right pleural space was opened, and the right phrenic nerve was located. A large rectangular flap of pericardium was cut, leaving it pedicled on the right side to preserve its vascular connections.

The flap was rolled and made into a tube. The diameter of the pedicled pericardial tube corresponded to that of the IVC; the length was determined by the distance between the IVC and the pulmonary artery (18×70 mm; Fig 1). The main pulmonary artery and left pulmonary artery were dissected and mobilized.

The patient was given heparin (1 mg/kg). The superior vena cava (SVC) was cannulated near the innominate vein with a 21F, right-angled venous cannula. A 30F venous cannula was placed in the right atrium and connected to the SVC venous cannula with a short segment of pump tubing, avoiding kinking (Fig 2). With this venous shunt open the SVC was test occluded, producing no change in blood pressure, SVC pressure, or oxygen saturation.

With the temporary bypass, the SVC was clamped and transected above the cavoatrial junction. The cardiac end of the SVC was closed with 6-0 Prolene polypropylene (Ethicon Inc, Somerville, NJ). Care must be taken not to damage the sinus node area.

The mobilization of the SVC and the right pulmonary artery and its branches was then completed. A large side-biting clamp was applied to the right pulmonary artery, and a long incision was made on the superior aspect of the right pulmonary artery. The opening in the right pulmonary artery was then extended centrally.

The bidirectional cavopulmonary anastomosis was then carried out with a running suture of 6-0 Maxon polyglyconate (Davis & Geck, Danbury, Conn) to the posterior wall and with an interrupted suture of 6-0 Prolene polypropylene to the anterior wall, to avoid a purse-string effect and to maintain a wide anastomosis. The clamp was then released.

The IVC was dissected free from the diaphragm and cannulated just above the diaphragm with a 24F right-angled

venous cannula. The previously placed 30F right atrial cannula and the IVC cannula were connected with a short segment of pump tubing.

With this venous shunt open the IVC was test occluded, producing no change in blood pressure, IVC pressure, or oxygen saturation. A snare was passed around the IVC and snugged down onto the venous cannula. After a clamp was placed at the base of the right atrium, avoiding the coronary sinus, the atrium was transected below the clamp, leaving a beveled cuff of atrial wall attached to the IVC. The stump of the right atrium was oversewn with 2 layers of 6-0 Prolene polypropylene. An 18-mm pedicled pericardial roll was anastomosed end to end to the IVC with a running suture of 6-0 Maxon polyglyconate to the posterior wall and with an interrupted 6-0 Prolene polypropylene suture to the anterior wall. A longitudinal incision was made in the underside of the right pulmonary artery and extended centrally.

The largest possible anastomosis was made with the upper portion of the pericardial roll to match the internal diameter of the IVC and the right pulmonary artery. Air was evacuated from the pericardial roll. The SVC and IVC snares were released. The patient was weaned from temporary bypass in stable condition. The main pulmonary artery was clamped and transected. The cardiac and pulmonary artery ends were closed with a running suture of 5-0 Prolene polypropylene (Fig 3).

The immediate postoperative course was uneventful. The patient was extubated the next morning. Chest tubes were removed on the third postoperative day. Central venous pressures were equal in the SVC and IVC, averaging 12 mm Hg. A nonchylous pleural effusion developed and required 1 aspiration. Hemodynamic studies and angiography performed 3 months after total cavopulmonary connection with autologous pedicled pericardium demonstrated a wide, unobstructed conduit without caval and pulmonary stenosis. Ventilation-perfusion scans of the lungs were obtained, with good results. The patient is in sinus rhythm and doing well without medication 18 months after the operation. Surveillance for clot formation and conduit stenosis has been done by routine echocardiography.

Discussion. An extracardiac conduit for cavopulmonary connection may reduce turbulence. These extracardiac repairs may avoid the complications related to intracardiac repairs, thrombosis and atrial arrhythmias. The extracardiac route of the Fontan procedure also may reduce the systemic thromboembolic risk by eliminating an intracardiac patch or baffle material.[2-5] Emboli should be eliminated because no foreign material exists. The extracardiac cavopulmonary connection with autologous pedicled pericardial roll forms a compressible, nonthrombogenic conduit with growth potential. The hemodynamic consequence of this extracardiac conduit is better distribution of perfusion to both lungs. This was verified when ventilation-perfusion scans of the lungs were obtained. The risk for atrial arrhythmias may also be decreased by avoiding extensive right atrial suture lines.

Cardiopulmonary bypass is known to activate inflammatory mediators, increase lung water, and decrease right ventricular compliance. These unfavorable effects of cardiopulmonary bypass can increase pulmonary vascular resistance and decrease pulmonary blood flow after cavopulmonary connection. If intracardiac repair is not necessary, the extracardiac total cavopulmonary connection could be performed without cardiopulmonary bypass. There is no need to use myocardial ischemia to construct these anastomoses outside the heart. The postoperative course in our patient was uneventful. Construction of an extracardiac cavopulmonary connection with an autologous pedicled pericardial roll may represent the optimal Fontan connection, because these connections are easier to construct without cardiac arrest, use no foreign material, and have the potential of growth in width and length. A large number of patients and a longer follow-up will be mandatory to assess the exact degree of freedom from arrhythmias or other unforseen complications.

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